3.4 Noise and Vibration

This section identifies potential noise and vibration impacts on sensitive receptors or receivers, such as people in residential areas, schools, and hospitals, for the No Project and HST Alignment Alternatives[1]. This analysis generally describes the sensitive noise receptors in the region and the methodology for determining the potential noise and vibration impacts on those receptors for each HST Alignment Alternative. The differences in potential impacts among the HST Alignment Alternatives are compared to each other. This comparison considers the potential noise impacts from airplanes, automobiles on intercity highways, and the proposed HST system. The section also discusses the potential noise benefits of adding grade separations[2] for existing railroads in some areas and eliminating noise-generating at-grade crossings. Because this is a program-level environmental document, the analysis of potential noise and vibration impacts broadly compares the relative differences in potential impacts among the alternatives.

3.4.1 Regulatory Requirements and Methods of Evaluation

A. REGULATORY REQUIREMENTS

Noise and vibration are environmental issues evaluated under CEQA and NEPA for a proposed HST project.

Federal Noise Emission Compliance Regulation

The FRA has a regulation governing compliance with the Noise Emission Compliance Regulation adopted by the EPA for noise emissions from interstate railroads. The FRA's Railroad Noise Emission Compliance Regulation (49 CFR Part 210) prescribes minimum compliance regulations for enforcement of the railroad noise emission standards adopted by the EPA (40 CFR Part 201).

California Noise Control Act

At the state level, the California Noise Control Act was enacted in 1973 (Health and Safety Code § 46010 *et seq.*) and provides for the Office of Noise Control in the Department of Health Services to provide assistance to local communities developing local noise control programs and work with the Office of Planning and Research to provide guidance for the preparation of the required noise elements in city and county general plans, pursuant to Government Code § 65302(f). In preparing the noise element, a city or county must identify local noise sources and analyze and quantify, to the extent practicable, current and projected noise levels for various sources, including highways and freeways, passenger and freight railroad operations, ground rapid transit systems, commercial, general, and military aviation and airport operations, and other ground stationary noise sources, these would include HST alignments. Noise-level contours must be mapped for these sources, using both community noise equivalent level (CNEL) and day-night average level (L_{dn}), and are to be used as a guide in land use decisions to minimize the exposure of community residents to excessive noise.

1 See Section 3.0, Introduction, for an explanation of how this section fits together with the HST Network Alternatives presented in Chapter 7, as well as for an overview of the information presented in the other chapters.

2 For this analysis, a grade separation is the literal separation, using overpasses or underpasses, of the rail and roadway components of an at-grade crossing. This eliminates the need for trains to blow horns or sound warning devices at the grade separated (previous grade crossing) locations.

B. METHOD OF EVALUATION OF IMPACTS

Assessment of the HST Alignment Alternatives is based on relevant criteria adopted by the FRA (U.S. Department of Transportation 2005), FHWA (U.S. Department of Transportation 1998), and FTA (Federal Transit Administration 2006), each of which has established criteria for assessing noise impacts. The FRA has established criteria for assessment of noise and vibration impacts for high-speed ground transportation projects, with speed over 125 mph, as presented in the FRA High Speed Ground Transportation Noise and Vibration Assessment (U.S. Department of Transportation 2005). The methodology and impact criteria for noise and vibration from this FRA guidance manual have been used in the assessment of the HST Alignment Alternatives in areas with speed over 125 mph. In areas with train speeds under 125 mph, the FTA criteria for assessment of noise and vibration impacts, as found in Transit Noise and Vibration Impact Assessment (Federal Transit Administration 2006), has been used in the assessment of the HST Alignment Alternatives. As described below, each agency's criteria were used to define a screening distance for assessing the potential for noise impact from relevant sources. The FRA and FTA have also established vibration impact criteria related to rail transportation.

Two basic evaluation techniques were used for analysis of the HST: a screening analysis and a more specific analysis of typologies derived from representative HST locations. The representative typologies were used to verify screening-level assumptions and to provide a basis for comparison of HST Alignment Alternatives, including consideration of the potential effectiveness of mitigation and the potential impacts or benefits associated with grade separation of existing rail lines.

Screening Procedure

Transportation noise impacts are assessed according to the number of people and noise-sensitive land uses potentially impacted by new noise sources from a project. However, at the program level (especially before many project-level details of the proposed HST system have been defined) it is not possible to develop a specific measure of the noise impacts. Consequently, a screening method was used to develop a general estimate of the relative potential for noise and vibration impact among HST Alignment Alternatives. Screening distances were applied from the center of alignments to estimate all potentially impacted land uses in noise-sensitive environmental settings. The screening distances used are defined in the statewide program EIR/EIS (California High-Speed Rail Authority and Federal Railroad Administration 2005, Appendix 3.4-A). Based on census data, the number of people and noise-sensitive land uses were estimated within the defined screening distance. The rating methods used to determine these numbers are also described in the statewide program EIR/EIS (California High-Speed Rail Authority and Federal Railroad Administration 2005, Appendix 3.4-A). The method is conservative in that it overestimates the potential for impact. The method identifies all potentially impacted developed lands by type of use within the study area, but subsequent project-level analysis using better-defined system parameters and land use information is likely to indicate lower levels of potential impact. Because potential noise impacts decrease dramatically if a structure or land form blocks the path to the receptor, this is a conservative approach.

Noise screening analyses were performed for the HST Alignment Alternatives based on criteria established by the FRA and FTA for HST and conventional rail. The analyses were accomplished using available GIS data for land use and alignment geometry for each alignment. The number of people potentially affected and the area of noise-sensitive land uses within the screening distance were determined using GIS and census data.

The analyses were subsequently combined to develop an impact rating for each alignment alternative (see Environmental Consequences). The impact rating for each alignment alternative is described as low, medium, or high, as an indication of the potential for noise impact.

Rating the severity of impacts requires an assessment of how many people are exposed to impact-level noise and vibration. Consequently, a metric describing the relative magnitude of impact was developed.

Impact Metric = (Residential Population in the Impact Area/Mile) + 0.3 × (Mixed Use Population in the Impact Area /Mile) + (100 × Number of Hospitals in the Impact Area)/Mile + (250 × Number of Schools in the Impact Area)/ Mile

For this screening study, the impact metrics and impact ratings are defined in Table 3.4-1. The rating scheme is designed to indicate the potential for noise and vibration impacts along the alignment alternatives.

Table 3.4-1
Ratings Used for Noise and Vibration Analysis

Rating	Impact Metric	
	Noise	**Vibration**
Low	Less than 80	Less than 40
Medium	80–200	40–100
High	Greater than 200	Greater than 100

Application of Screening Method to Conventional Rail and High-Speed Train Modes

Railroad noise and vibration criteria developed by FTA are consistent with criteria adopted by the FRA for HSTs. Criteria for HST noise impact assessment are based on activity interference and annoyance ratings developed by EPA. These criteria, described and presented in graphical form in the statewide program EIR/EIS (California High-Speed Rail Authority and Federal Railroad Administration 2005, Appendix 3.4-A), provide the basis for the rail noise analysis procedures used in the screening and the representative typologies (U.S. Department of Transportation 2005).

The screening procedure used by the FRA takes into account the noise impact criteria, the type of corridor, and the ambient noise conditions in typical communities. Distances within which potential impacts may occur are defined based on operations of a typical HST system. These distances were developed from detailed noise models based on empirical measurements of noise emissions of existing steel-wheel/steel-rail HSTs, expected maximum operation levels and speeds, and residential land use. The width of the potential impact along the length of the HST alignment is the area in which there is potential for noise impact. The FRA screening procedure was developed for HST speeds from 125 to 210 mph (201 to 338 kph). For speeds less than 125 mph (201 kph) and for areas near stations, the FTA screening method was used in concert with the FRA method. The average speed along the HST Alignment Alternatives was used to determine the screen distance. The FRA and FTA screening distances for noise are included in the statewide program EIR/EIS (California High-Speed Rail Authority and Federal Railroad Administration 2005, Appendix 3.4-A).

The screening distances are different for the different types of developed areas along a potential alignment, according to their estimated existing ambient noise. *Urban* and *noisy suburban* areas are grouped together. These areas are assumed to have ambient noise levels greater than 60 dBA L_{dn}. Similarly, *quiet suburban*, *rural,* and *natural open-space* areas are grouped as areas where ambient noise levels are less than 55 dBA L_{dn}. For developed land with L_{dn} between 55 and 60 dBA, the classification depends on other factors, such as proximity of major transportation facilities and density of population. The screening procedure was applied to first allow for the comparison of impacts between alternatives and to identify areas of potential impacts for further consideration in project-level analysis. The screening procedure estimates the affected receptors to ensure that all potential impacts are included at the program level.

Although the screening procedure is based on the type of equipment (technology and power type), operational characteristics of the new services (speeds and frequencies), the type of support structure (aerial or at-grade), and the general ambient noise level, it does not address the horn and bell noise associated with existing passenger and freight trains because these are regarded as part of the existing environment. To develop a relative comparison of the HST Alignment Alternatives, the results of the screening analysis were adjusted to account for noise reductions from the elimination of at-grade crossings on existing rail lines, where the HST Alignment Alternatives would share the rail corridor. The degree of adjustment was based on the representative typologies for similar circumstances and is defined in the following section.

As a final step for those areas rated medium or high for potential impacts, the screening analysis assessed the potential use of noise barriers and other mitigation options to reduce noise impacts. The mitigation analysis is discussed in Section 3.4.5.

The vibration screening procedure was used to compare potential impacts among HST alignments and to provide an estimate of the length of alignments where consideration of vibration attenuation features may be appropriate.

Representative Typologies for High-Speed Trains

To better understand the potential impacts of the HST, several noise impact assessment studies were previously prepared for representative situations of noise- and vibration-sensitive land uses in the statewide program EIR/EIS (Authority and FRA, November 2005). The more detailed General Assessment Method of FTA's and FRA's guidance manuals were used to estimate the potential for noise impacts. These typological studies verified the general results from the screening procedure. Representative situations were chosen to provide a range of potential impact types and levels. This approach provided a means of considering at the program level the potential impacts on communities along any potential proposed HST alignment.

Developed land use categories consist of individual medium- and low-density residential zones, schools, hospitals, parks, and other unique institutional receptors such as museums and libraries. Residential land uses were chosen for the typologies for new and shared corridors that varied in local zoning densities, ambient noise conditions, set back distances from the alignment, and HST operational speeds. Institutional uses, as mentioned above, and parks were individually identified for each focused study. These representative typologies evaluated the topics listed below.

- Verification of screening distances (noise and vibration).
- Effectiveness of noise barriers.
- Benefits from elimination of grade crossings.
- Costs and benefits of a high-speed downtown bypass loop.

Verification of Screening Distances (Noise and Vibration)

The analyses of the representative typologies confirmed that the screening method used an appropriate upper boundary as an indicator of potential for noise impact. Impacts were found to occur in 90% of the cases identified in the screening procedure; in 75% of those studied, consideration of mitigation may be appropriate. Those that would have insignificantly low noise impact were either at outer edges of the screening distance or were shielded sufficiently by other buildings. Shielding by terrain features or buildings is not taken into account in the screening process but would be included in the subsequent project-level analyses of HST segments.

Representative typology studies were also completed that assess the range of the potential vibration impact levels that are likely to be encountered in project-level analyses. The results generally show that the closer buildings would be to a proposed alignment, the greater the likelihood of impact. Where speeds are expected to be low, the vibration potential impacts are confined to within 100 ft (30 m) of the track. At top speeds, the potential impacts extend to 200 ft (61 m). The special typologies generally validate the vibration screening distances that are included in the statewide program EIR/EIS (California High-Speed Rail Authority and Federal Railroad Administration 2005, Appendix 3.4-A).

Effectiveness of Noise Barriers

Noise barriers are used extensively in Europe and Japan to mitigate noise impacts from HST systems. The representative typology studies generally indicated that mitigation by sound barrier walls can be an effective means of reducing the potential impacts by one category, for example, from severe impact (mitigation appropriate) to impact. Noise barrier mitigation is shown to be especially effective for receivers close to the tracks. Although noise barrier walls would not be the only potential mitigation strategy considered, they were used to represent mitigation potential in the statewide program EIR/EIS (California High-Speed Rail Authority and Federal Railroad Administration 2005) and in this Program EIR/EIS.

Benefits from Elimination of Grade Crossings

The representative typology studies were also used to estimate the potential benefit of noise reduction resulting from grade separations. A focused noise study in the Bay Area to Central Valley region (at Charleston Road in Palo Alto) showed the potential benefit of eliminating horn blowing at a typical Caltrain grade crossing on the San Francisco Peninsula. Assessment of noise impact from horns at-grade crossings was performed with FRA's horn noise model and annoyance based criteria. The horn noise model indicated an 81% reduction in the number of people impacted within 0.25 mi (0.40 km) of that intersection by elimination of horn noise from commuter trains. Although the results vary depending on the local population density and proximity of residences and other sensitive land uses at each grade crossing, they illustrate the magnitude of the potential change to be expected if the sounding of horns and bells at existing rail crossings could be eliminated.

Removing all potential remaining horn noise would not eliminate noise impacts, however, because the sound of the trains would remain. The proposed HST would add its own noise to that of other trains using the railroad corridor. Carrying the focused study further, it was found that approximately 75% of the at-grade crossings to be eliminated with the proposed HST system are located adjacent to residential areas with a high potential noise impact rating. Although there would be a clear benefit from the elimination of the horns and warning signals, there would be additional train noise and vibration primarily from the high train speed and frequency of service.

Based on these results, the potential noise impact ratings from screening were adjusted to account for segments where at-grade crossings would be eliminated for existing passenger and freight trains as part of the implementation of HST service along that alignment. A reduction in one impact rating level (high to medium or medium to low) was made only for alignments where HST speeds would be less than 150 mph (241 kph). Where speeds were above that level, no adjustment was made because the noise created by the proposed new service at higher speeds would likely overshadow the reduction in horn and bell noise resulting from the grade separation.

This adjustment was made on the alignments listed below.

- Caltrain Corridor from San Francisco to San Jose.
- Niles subdivision line from south of Oakland to north of Warm Springs.
- UPRR line on the Altamont crossing.
- UPRR and BSNF corridors in the Central Valley.

C. CEQA SIGNIFICANCE CRITERIA

At the programmatic level, the project would cause a significant noise or vibration impact under CEQA if it would result in:

- Potential exposure of persons to or generation of noise levels in excess of standards established by the FRA for high-speed ground transportation and by the FTA for rail projects.
- Potential exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels.
- A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project.
- A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project.

D. METHOD OF EVALUATION OF POTENTIAL IMPACTS ON WILDLIFE

The potential for direct effects of train noise on wildlife in natural areas is not well documented. There are no established criteria relating high-speed train noise and animal behavior. However, some characteristics of high-speed train noise are similar to low overflights of aircraft, and researchers generally agree that high noise levels from aircraft overflights can have a disturbing effect on both domestic livestock and wildlife. Some animals get used to noise exposure, while some do not. Documented effects range from simply taking notice and changing body position to taking flight in panic. Whether these responses represent a threat to survival of animals remains unclear, although panic flight may result in injuries to animals in rough terrain or in predation of unprotected eggs of birds. A limited amount of quantitative noise data relating actual levels to effects provides enough information to develop a screening procedure to identify areas where noise from HST operations could affect domestic and wild animals. The basis for the screening is the interim criteria for HST noise effects on animals shown in Table 3.4-2.

Figure 3.4-1 presents the screening distances at which a train passby with a sound exposure level (SEL) of 100 dBA would occur for different operating speeds. Wildlife in natural areas would be minimally affected by train passbys at speeds of up to 180 mph at distances of 60 ft or more.

Table 3.4-2
Interim Criteria for High Speed Train Noise Effects on Animals

Animal Category	Class	Noise Metric	Noise Level
Domestic	Mammals (livestock)	Sound exposure level	100
	Birds (poultry)	Sound exposure level	100
Wild	Mammals	Sound exposure level	100
	Birds	Sound exposure level	100
Source: High Speed Ground Transportation Noise and Vibration Assessment 2005.			

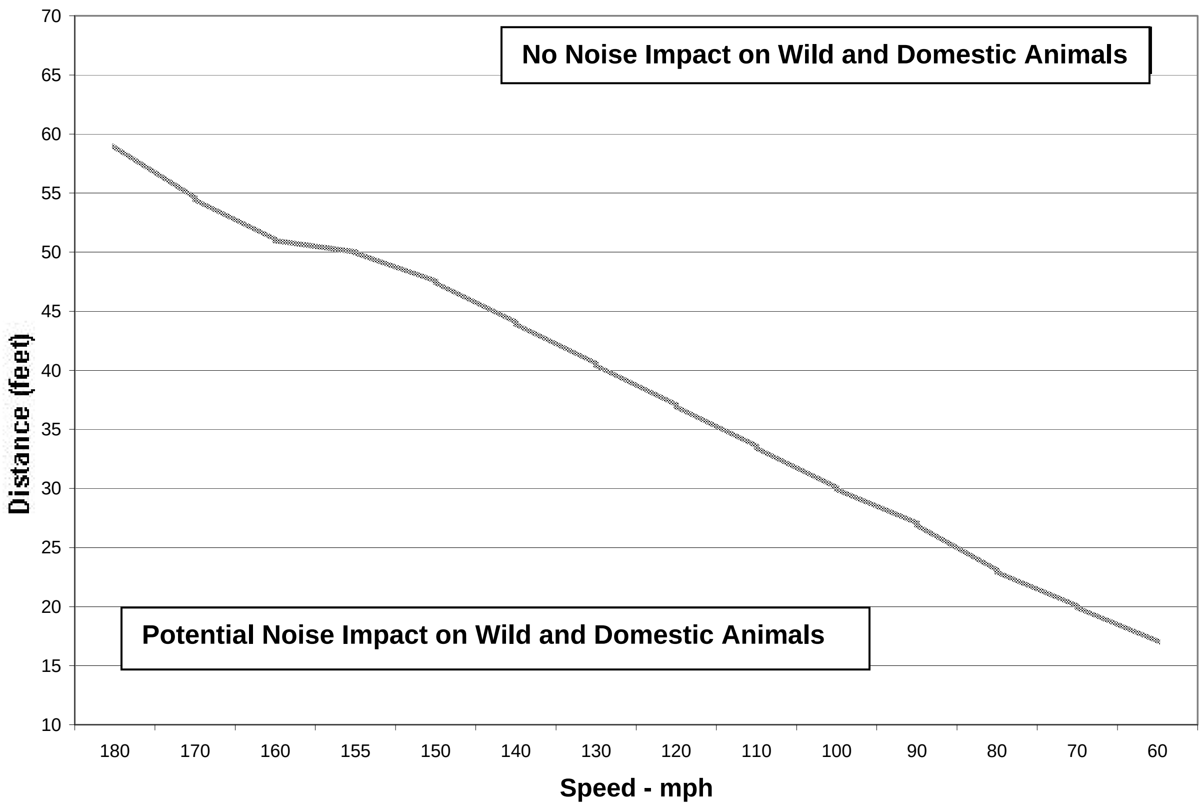


Figure 3.4-1
Wildlife Impacts at Different Setback Distances and Train Speeds

The HST project's potential noise and vibration impacts on wildlife will be evaluated further at the project level when speed, noise, and vibration may be more precisely calculated and field surveys may be performed to identify potentially affected wildlife.

E. METHOD OF EVALUATION OF POTENTIAL IMPACTS ON PRISTINE OPEN SPACES

Noise thresholds have been selected as a means by which HST noise impacts on pristine areas with very quiet ambient sound levels can be measured. None of these thresholds are associated with a specific FRA, FTA, or other criteria or standards for rail noise; however, they are all considered useful in describing the potential for impact on pristine areas where the existing ambient noise levels are less than 50 dBA. They are based on past experience with the effects of military and civilian aircraft overflights on national parks.

Human cognitive effects of HST operations are interference and annoyance. Interference is the precursor to annoyance, which means something that prevents persons from doing what they want to do; interference is an interruption or distraction. Annoyance means having an emotional reaction to noise interference. Low levels of HST noise can result in interference but not necessarily result in annoyance. The number and frequency of HST operations must exceed a certain level or threshold before it is perceived as annoying. Interference is a short-term occurrence. Annoyance, because of the emotional component is more long lasting. Annoyance is the more appropriate criteria in evaluating the receiver experience in pristine open spaces using the metric Time Audible (TA) – the percentage of time that aircraft sound levels are audible. This metric is used to assess the potential aviation noise annoyance to quiet outdoor areas with frequent human recreation and could be adapted for use at the project level for HST noise.

The other noise metric that could be used to assess potential impacts to pristine areas would be change in exposure (ΔL)—the algebraic difference (in A-weighted decibels) between HST noise levels and baseline ambient sound levels during the daily period when the HSTs operate. Generally, a change in 5 dB is considered noticeable to humans, and an increase of 10 dB is considered twice as loud. However, because the measurement period is 12 hours or longer, the noise level of a single-event HST passby would be much higher than the ambient noise level but would last for less than 15 seconds. As an indication of potential impacts to humans, this metric is not as good as annoyance.

Studies of the effects of military aircraft overflights on recreational uses of national parks have suggested a dose response relationship between percent annoyed and percent time audible (Miller 2001). The following guidelines, taken from this study, are used to assess the different air tour alternatives for parks. The average percent annoyed represent those visitors who felt that the aircraft flyovers interfered with their appreciation of natural quiet. Table 3.4-3 shows the dose response relationship between percent time audible and average percent of visitors annoyed.

Table 3.4-3
Dose Response Relationship between Time Audible and Visitor Annoyance

Percent Time Audible	Average Percent of Visitors Annoyed
10	3–4
20	6–8
30	10–12
40	14–16
50	19–21

Source: Miller 2001

HST operation noise would be limited to the areas that adjoin track alignments. The extent of the potential impacts would be determined by the train speed, number of power units and coaches, topographical features, and the existing ambient noise levels. To quantify these impacts, project-level studies would include detailed graphic plots of noise contours of HST operations in pristine open spaces to determine the area of potential effect.

3.4.2 Affected Environment

A. STUDY AREA DEFINED

The study area for the noise and vibration assessment is defined by the screening distances that are used by the FRA (U.S. Department of Transportation 2005) and FTA (U.S. Department of Transportation 2006) to evaluate rail lines. Study areas are within 1,000 ft (305 m) of the centerline of the alignment options for each alignment.

B. GENERAL DISCUSSION OF NOISE AND VIBRATION

This section describes the characteristics and associated terms and measurements used for transportation-related noise and vibration. When noise from a highway, plane, or train reaches a receptor, whether it is a person outdoors or indoors, it combines with other sounds in the environment (the ambient noise level) and may or may not stand out in comparison. The distant sources may include traffic, aircraft, industrial activities, or sounds in nature. These distant sources create a background noise in which usually no particular source is identifiable and to which several sources may contribute but is fairly constant from moment to moment and varies slowly from hour to hour. Superimposed on this slowly varying background noise is a succession of identifiable noisy events of relatively brief duration. Examples include the passing of a train, the over flight of an airplane, the sound of a horn or siren, or the screeching of brakes. These single events may be loud enough to dominate the noise environment at a location for a short time, and, when added to everything else, can be an annoyance. The descriptors used in the measurement of noise environments are summarized below.

The fundamental measure of noise is the dB, a unit of sound level based on the ratio between two sound pressures—the sound pressure of the source of interest (e.g., the HST) and the reference pressure (the quietest sound that a human can hear). Because the range of actual sound pressures is very large (a painful sound level can be over 1 million times the sound pressure of the faintest sound), the expression of sound is compressed to a smaller range with the use of logarithms. The resulting value is expressed in terms of dB. For example, instead of a sound pressure ratio of 1 million, the same ratio is 120 dB.

The human ear does not respond equally to high- and low- pitched sounds. In the 1930s, acoustical scientists determined how humans hear various sounds and developed response characteristics to represent the sensitivity of a typical ear. One of the characteristics, called the *A-curve*, represents the sensitivity of the ear at sound levels commonly found in the environment. The A-curve has been standardized. The abbreviation dBA is intended to denote that a sound level is expressed as if a measurement has been made with filters in accordance with that standard.

- *Maximum Sound Level (L_{max})*, measured in dBA, is the highest noise level achieved during a noise event.
- *Equivalent Sound Level (L_{eq})*, measured in dBA, describes a receptor's cumulative noise exposure from all noise events that occur in a specified period of time. The hourly L_{eq} is a measure of the accumulated sound exposure over a full hour. The L_{eq} is computed from the measured sound energy averaged over an hour (nothing one would read from moment to

moment on a meter) representing the magnitude of noise energy received in that hour. FHWA uses the peak traffic hour L_{eq} as the metric for establishing highway noise impact.

- *Day-Night Sound Level (L_{dn})* describes a receptor's cumulative noise exposure from all noise events that occur in a 24-hour period, with events between 10 p.m. and 7 a.m. increased by 10 dB to account for greater nighttime sensitivity to noise. The L_{dn} is used to describe the general noise environment in a location, the so-called "noise climate." The unit is a computed number, not one to be read from moment to moment on a meter. Its magnitude is related to the general noisiness of an area. EPA developed the L_{dn} descriptor, and now most federal agencies, including the FRA, use it to evaluate potential noise impacts. Typical L_{dn}s in the environment are shown in Figure 3.4-2.
- *CNEL*, a variant of L_{dn}, is used in noise assessments in California. Rather than dividing the day into two periods, daytime and nighttime, CNEL adds a third to account for increased sensitivity to noise in the evening when people are likely to be engaged in outdoor activities around the home. An evening addition of 5 dB is applied to noise events between the 7 and 10 p.m. to reflect the additional annoyance noise causes at that time. In general, the difference between L_{dn} and CNEL is slight, and the two measures will be considered interchangeable for purposes of this noise analysis.
- *Sound Exposure Level (SEL)* is the sound energy from a single event train passby. SEL is a cumulative measure of noise so (1) louder events have greater SELs than do quieter ones, and (2) events that last longer in time have greater SELs than do shorter ones.

The way people react to noise in their environment has been studied extensively by researchers throughout the world. Based on these studies, noise impact criteria have been adopted by the FRA (U.S. Department of Transportation 2005) and other federal agencies to assess the contribution of the noise from a source like the HST to the existing environment. The FRA bases noise impact criteria on the estimated increase in L_{dn} (for buildings with nighttime occupancy) or increase in L_{eq} (for institutional) buildings caused by the project for direct and indirect impacts. Criteria are discussed in Section 3.4.1.

Transportation Noise

Noise from highways, airports, and rail lines tends to dominate the noise environment in its immediate vicinity. Each mode has distinctive noise characteristics in both shape and source levels. Highway and rail noise affects an area that is linear in shape, extending to both sides of the alignment. Airport noise, in contrast, affects a closed area around the facility, with the shape of the closed loop determined by runway orientation.

Conventional and High-Speed Train Noise and Vibration

Although HSTs have some similar noise and vibration characteristics to conventional trains, they also have several unique features resulting from their reduced size and weight, the electrical power, and the higher speed of travel. The proposed HST would be a steel-wheel, steel-rail electrically powered train operating in an exclusive right-of-way. Because there would be no roadway at-grade crossings, the annoying sounds of the train horn and warning bells would be eliminated. The use of electrical power cars would eliminate the engine rumble associated with diesel-powered locomotives. The above factors allow HST to generate lower noise levels than conventional trains at comparable speeds below 100 mph (161 kph). At higher speeds above 150 mph (241 kph), however, HST noise levels would increase over conventional trains due to aerodynamic effects. A mitigating factor is that due to high speeds, HST noise would occur for a relatively short duration compared with conventional trains (a few seconds at the highest speeds versus 10–20 seconds for conventional passenger trains and over 1 minute for freight trains).

For the proposed HST system, higher operating speeds of 150–220 mph (241–354 kph) would occur in the less constrained areas, in terms of alignment (i.e., flat and straight). In contrast, much lower operating speeds (less than 125 mph [201 kph]) would be prevalent in the more developed areas. Figure 3.4-3 illustrates the maximum operating speeds for express service along each of the proposed HST Alignment Alternatives. Local and semi-express services would not necessarily reach these maximum speeds because they would stop and start for more stations.

Noise from a HST is expressed in terms of a source-path-receiver framework (Figure 3.4-4). The source of noise is the train moving on its tracks. The path describes the intervening course between the source and the receptor wherein the noise levels are reduced by distance, topographical and human-made obstacles, atmospheric effects, and other factors. Finally, at each receptor, the noise from all sources combines to make up the noise environment at that location.

The total noise generated by a train is the combination of sounds from several individual noise-generating mechanisms, each with its own characteristics, including location, intensity, frequency content, directivity, and speed dependence. The distribution of noise sources on a typical HST is shown in Figure 3.4-5. These noise sources can be grouped into three categories according to the speed of the train.

For low speeds, below about 40 mph (64 kph), noise emissions are dominated by the propulsion units, cooling fans, and under-car and top-of-car auxiliary equipment, such as compressors and air conditioning units. The HST would be electrically powered and considerable quieter at low speeds than conventional trains, which are usually diesel powered.

In the speed range from 60 mph to about 150 mph (98–241 kph), mechanical noise resulting from wheel-rail interactions and structural vibrations dominate the noise emission from trains. In the existing rail corridors in California, conventional trains seldom exceed 79 mph (127 kph), so this speed range, which represents a medium range for HST, is the top end of noise characteristics for trains with which most people are familiar. Speed has a strong influence on noise in the medium speed range.

Above approximately 170 mph (274 kph), aerodynamic noise sources tend to dominate the radiated noise from the HST. Conventional trains are not capable of attaining such speeds. HST noise in the transition speeds between each of the three foregoing ranges is a combination of the sources in each range.

Noise from HST also depends on the type and configuration of its track structure. Typical noise levels are expressed for HST at grade on ballast and tie track, the most commonly found track system. For trains on elevated structure, HST noise is increased, partially due to the loss of sound absorption by the ground and partially due to extra sound radiation from the bridge structure. Moreover, the sound from trains on elevated structures spreads about twice as far as it does from at-grade operations of the same train because of clearer paths for sound transmission.

Horns are an example of a train noise source that is a dominant noise source at any speed. Audible warnings for at-grade crossings, including train horns and warning bells, are a common feature of conventional trains and a vital safety component of railroad operations. These noise sources often prove to be a source of annoyance to people living near railroad tracks. In the case of HST, however, horn and warning bell noise are absent except in the case of emergencies because at-grade crossings are eliminated. Reduction of horn and bell noise from the elimination of existing at-grade crossings would provide a noise benefit associated with the implementation of HST for alignments along existing rail corridors, but only at locations where grade separations are built that serve both the HST system and existing rail lines.

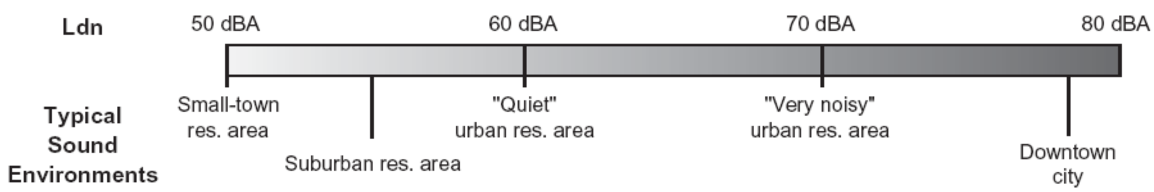


Figure 3.4-2
Typical Day-Night Sound Level Environments

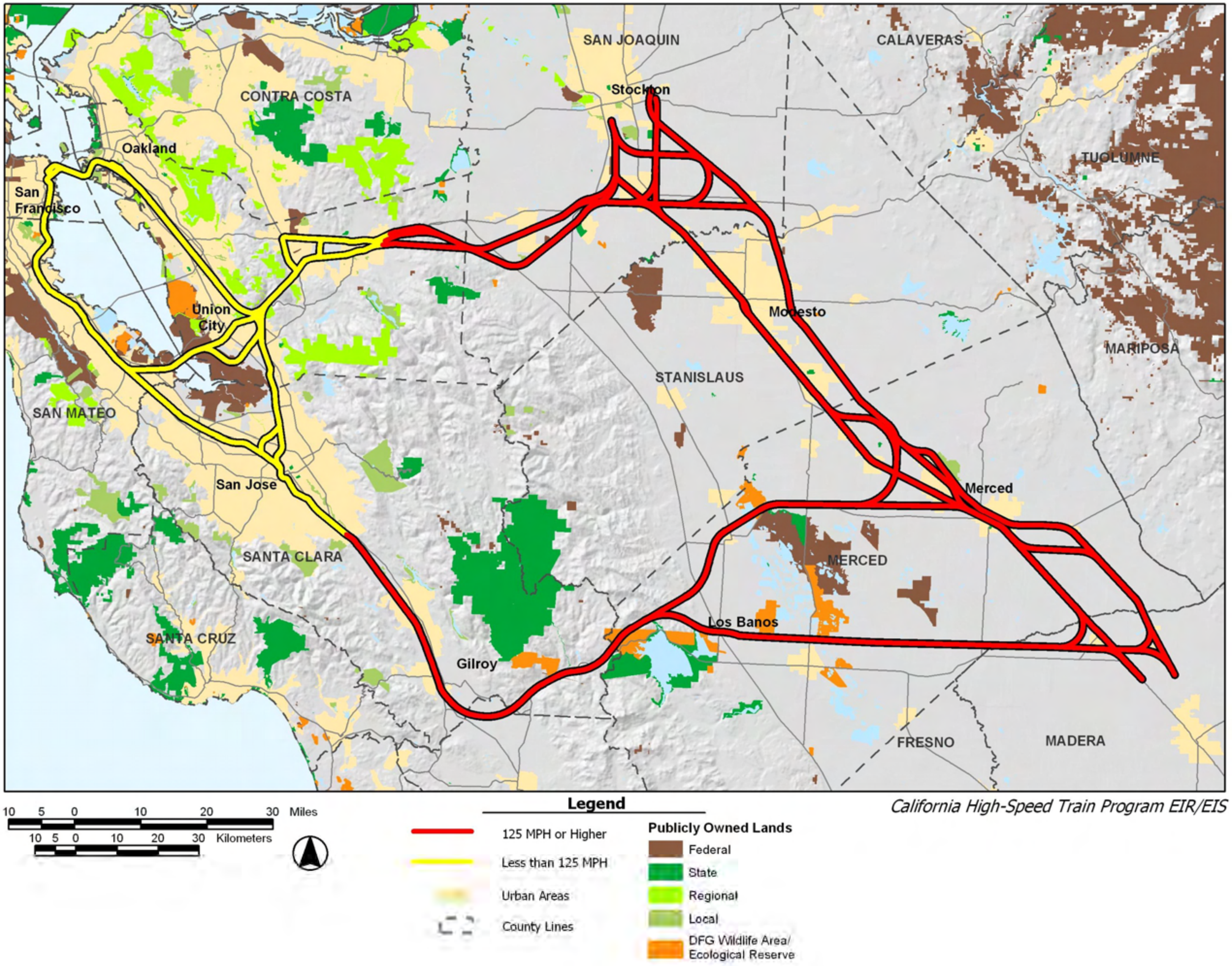


Figure 3.4-3
Potential Average Operating Speeds

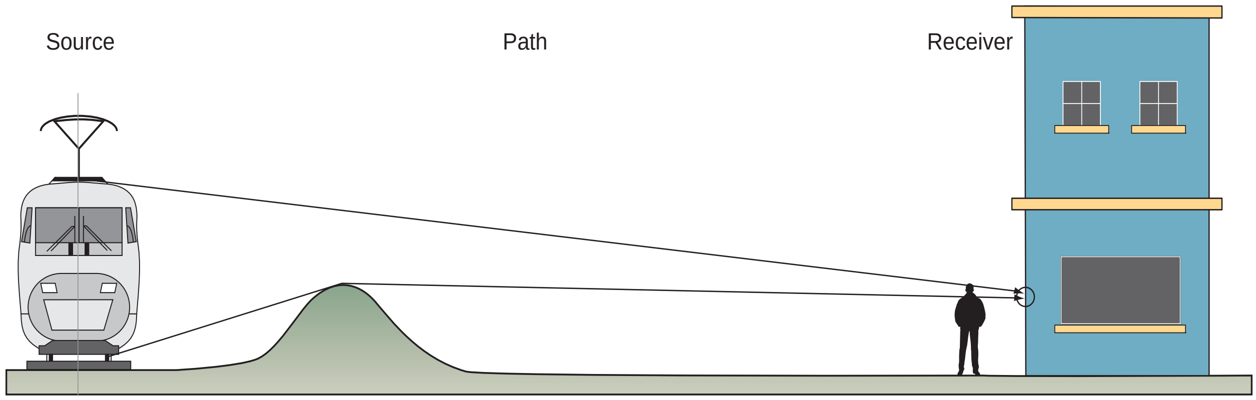


Figure 3.4-4
HST Source Path Receiver Framework

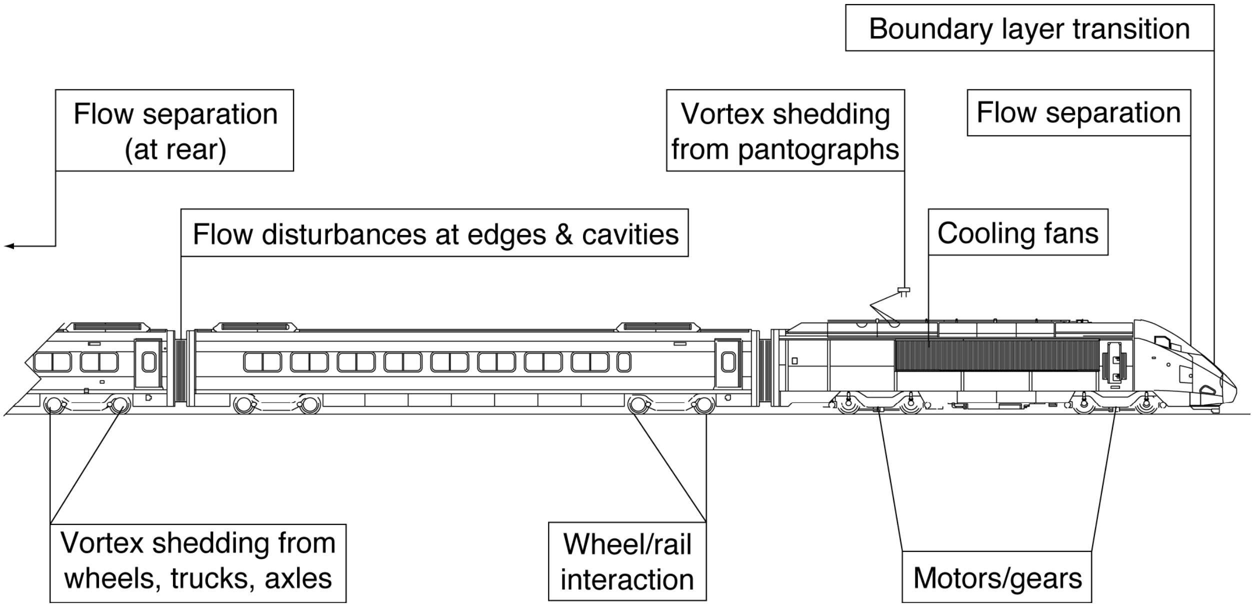


Figure 3.4-5
Noise Sources on HST

Vibration of the ground caused by the pass-by of the HST is similar to that caused by conventional steel wheel/steel rail trains. However, vibration levels associated with the HST are relatively lower than conventional passenger and freight trains due to advanced track technology, smooth track and wheel surfaces, and high maintenance standards required for high-speed operation.

Ground-borne vibration from trains refers to the fluctuating motion experienced by people on the ground and in buildings near railroad tracks. In general, people are not commonly exposed to vibration levels from outside sources that they can feel. Little concern results when a door is slammed and a wall shakes or something heavy is dropped and the floor shakes momentarily. Concern results, however, when an outside source like a train causes homes to shake. The effects of ground-borne vibration in a building located close to a rail line could at worst include perceptible movement of the floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. None of these effects are great enough to cause damage but could result in annoyance if repeated many times daily.

As with noise, ground-borne vibration can be understood as following a source-path-receptor framework (Figure 3.4-4). The source of vibration is the train wheels rolling on the rails. They create vibration energy that is transmitted through the track support system into the track bed or track structure. The path of vibration involves the ground between the source and a nearby building. The receptor of vibration is the building.

C. EXISTING NOISE ENVIRONMENT

Existing noise environments are generally dominated by transportation-related sources, including vehicle traffic on freeways, highways, and other major roads, existing passenger and freight rail operations, and aviation sources, including civilian and military. Existing noise along highway and proposed HST corridors has been estimated using data in the noise element from the general plan for cities and counties in the region, along with general methods provided by FHWA, FRA, and FTA for estimating transportation noise. Ambient noise levels are characterized for below. Ambient vibration conditions are very site-specific in nature and are not characterized as part of the program environmental process.

The study region is central California from the San Francisco Bay Area (San Francisco and Oakland) south to the Santa Clara Valley and east across the Diablo Range to the Central Valley. The ambient noise in the northern portion of the Bay Area to Central Valley region is dominated by motor vehicle traffic in densely populated areas and along freeways. All the regional freeways considered in the No Project Alternative are major contributors to the ambient noise environment. In this region, the HST Alignment Alternatives would primarily follow or parallel existing rail tracks. Along the proposed alignment alternative on the San Francisco Peninsula, the Caltrain passenger service is a major contributor to the ambient noise levels, especially at grade crossings, where horn noise dominates the noise environment within 0.25 mi (0.40 km) of the intersections. Along the proposed East Bay Crossings alignment, existing Amtrak passenger service and freight rail contribute to the ambient noise levels, with horns at grade crossings being a major factor. In southern San Jose and as far as Gilroy to the south, Caltrain, Amtrak, and freight rail are major contributors to the ambient noise levels.

In the urban areas and suburban areas of the East Bay, San Francisco Peninsula, and San Jose, the ambient noise is estimated to range from L_{dn} 57 to 66 dBA. In many of the residential areas close to the international airports at San Francisco (SFO), Oakland (OAK), and San Jose (SJC), the ambient levels exceed L_{dn} 65 dBA. In the more rural areas of the region to the southeast, the ambient noise ranges from 52 to 57 dBA. Henry Coe State Park is characterized by a low ambient noise environment, approximately L_{eq} 40 dBA, because it is in a remote location and removed from transportation noise sources, except in the southern area, which is approximately 5 miles from SR 152.

In areas away from major roadways, noise from local noise sources is estimated using a relationship determined by the EPA. EPA determined that ambient noise can be approximately related to population density in locations away from transportation corridors, such as airports, major roads, and railroad tracks, according to the following relation:

L_{dn} = 22+ 10 log *(p)* (in dBA)

where *p* = population density in people per square mile.

3.4.3 Environmental Consequences

A. NO PROJECT ALTERNATIVE

The No Project Alternative includes programmed and funded transportation improvements that will be implemented and operational by 2030, in addition to the existing conditions. These improvements are not major systemwide capacity improvements (e.g., major new highway construction or widening or additional runways) and will not result in a general improvement of intercity travel conditions across the study region.

For purposes of this analysis, it is assumed that there will be no additional noise and vibration impacts associated with the development of the No Project Alternative, as compared to existing conditions. The potential significant impacts associated with programmed projects would be addressed with mitigation measures in a manner consistent with existing conditions in accordance with the project-level environmental documents and approvals for the projects as prepared by the project sponsors. Although the implementation of the No Project Alternative may result in some increases, any estimate of such increases would be speculative.

B. HIGH-SPEED TRAIN ALIGNMENT ALTERNATIVES

It is assumed that any improvements associated with the HST Alignment Alternatives and stations location options would be in addition to No Project conditions.

The existing Caltrain alignment along the San Francisco Peninsula and the East Bay railroad alignments pass through densely populated communities where there is high potential for noise impacts. The potential noise impacts of the proposed HST service through these areas would result primarily from the greater frequency of trains, since the HST service would be operating at reduced speeds and would create noise levels similar to the existing services. The HST system would be expected to result in the elimination of up to 48 grade crossings on the peninsula and up to 38 grade crossings on the East Bay. Grade separation of existing rail services would result in considerable benefits from the elimination of the warning bells at existing at-grade crossings and the horn blowing of the existing commuter/intercity services along these alignments.

All the options for mountain crossings between the Bay Area and the Central Valley pass through sparsely populated areas but would introduce new noise sources along corridors through wilderness areas where the alignment is at grade or elevated. Along the Pacheco alignment from Diridon to Gilroy, there are 42.4 miles where noise impacts are rated medium to high and vibration impacts are rated medium. Four schools are located along this alignment, with 131 ac of parkland and varying residential populations. Through the Altamont Pass, there are 1.7–9.7 mi of sparsely populated areas where noise and vibration impacts are rated medium to high.

The relative level of potential noise and vibration impact for each HST alternative segment is shown in Table 3.4-4 and Figure 3.4-6. The table includes the length of alignment alternatives, residential population, mixed use population, acreage of parkland, number of schools, and number of hospitals. At a program level of analysis, station locations will not affect the impact rating of the alternative segments, so no data was included in Table 3.4-4. A detailed data table is included in Appendix 3.4-A.

In general the noise and vibration impact ratings are based on the population densities along each of the segments and the proximity of parkland, hospitals, and schools. Segments where trains would operate at higher speeds would have a greater level of impact. The comparison of the alignment alternatives is based on the data presented in Table 3.4-4 and Figure 3.4-6. Appendix 3.4-A provides a comparison of the alternative alignments by segment.

Potential noise and vibration impacts on wildlife and pristine open space from the HST system cannot be analyzed and ranked at the programmatic level of this report. At the programmatic level, the location and density of wildlife is undetermined, as are the types of wildlife along the HST Alignment Alternatives. Areas of pristine open space need to be defined and mapped based on more precise project-specific information. The significance of noise and vibration impacts of the HST Alignment Alternatives on wildlife and on pristine open space is therefore speculative at this time. Future project-level analyses should include a detailed study of the location, type, and density of wildlife in the project area. The boundaries of pristine open space should be defined and mapped during the project level analyses, so that the amount of pristine open space affected by noise and vibration from the HST Alignment Alternatives can be calculated.

<u>San Francisco to San Jose</u>

Although the HST service in the San Francisco to San Jose (Caltrain) corridor would be going through densely populated communities, the alignment alternatives in this corridor were rated as having a medium level of potential noise impacts because the HST would be traveling at reduced speeds and the communities would benefit from grade separation improvements for existing services and electrification of the railroad.

The noise impacts along this corridor are rated low for those alignment alternatives that are either in a tunnel or passing through sparsely populated areas. The remaining alignment alternatives are rated medium because of the higher population density in proximity to the alignment and the existing parkland and two schools. Vibration impacts along the Transbay Transit Center to 4th/Townsend segment are low. The other alignment alternatives have the potential for medium to high vibration impacts because of the proximity of residential structures to the alignment.

Table 3.4-4
Noise and Vibration Impact Summary Data Table for
Alignment Alternatives and Station Location Option Comparisons

Corridor	Possible Alignments	Alignment Alternative	Total Segment (Miles)	Residential Population	Mixed Use Population	Parkland (Acres)	Hospitals	Schools	Noise Impact Rating*	Vibration Impact Rating
San Francisco to San Jose: Caltrain	1 of 1	San Francisco to Dumbarton	28.84	5,509.3	140.1	0.00	0	2	Medium	Medium
	1 of 1	Dumbarton to San Jose	21.61	9,456.3	62.1	5.27	0	0	Medium	High
Station Location Options										
Transbay Transit Center			Ratings are based on alignment alternative that station is on—San Francisco to Dumbarton						Low	Low
4th and King (Caltrain)			Ratings are based on alignment alternative that station is on—San Francisco to Dumbarton						Low	Low
Millbrae/SFO			Ratings are based on alignment alternative that station is on—San Francisco to Dumbarton						Medium	Medium
Redwood City (Caltrain)			Ratings are based on alignment alternative that station is on—San Francisco to Dumbarton						Medium	Medium
Palo Alto (Caltrain)			Ratings are based on alignment alternative that station is on—Dumbarton to San Jose						Medium	High
Oakland to San Jose: Niles/ I-880	1 of 2	West Oakland to Niles Junction	13.6	2,626.7	0.00	0.00	0	1	Medium	High
		12th Street/City Center to Niles Junction	13.56	2,636.5	0.00	0.00	0	1	Medium	High
	1 of 2	Niles Junction to San Jose via Trimble	13.09	1,949.6	87.9	67.44	0	1	Medium	Medium
		Niles Junction to San Jose via I-880	25.55	2,032.9	95.4	67.44	0	1	Medium	Medium

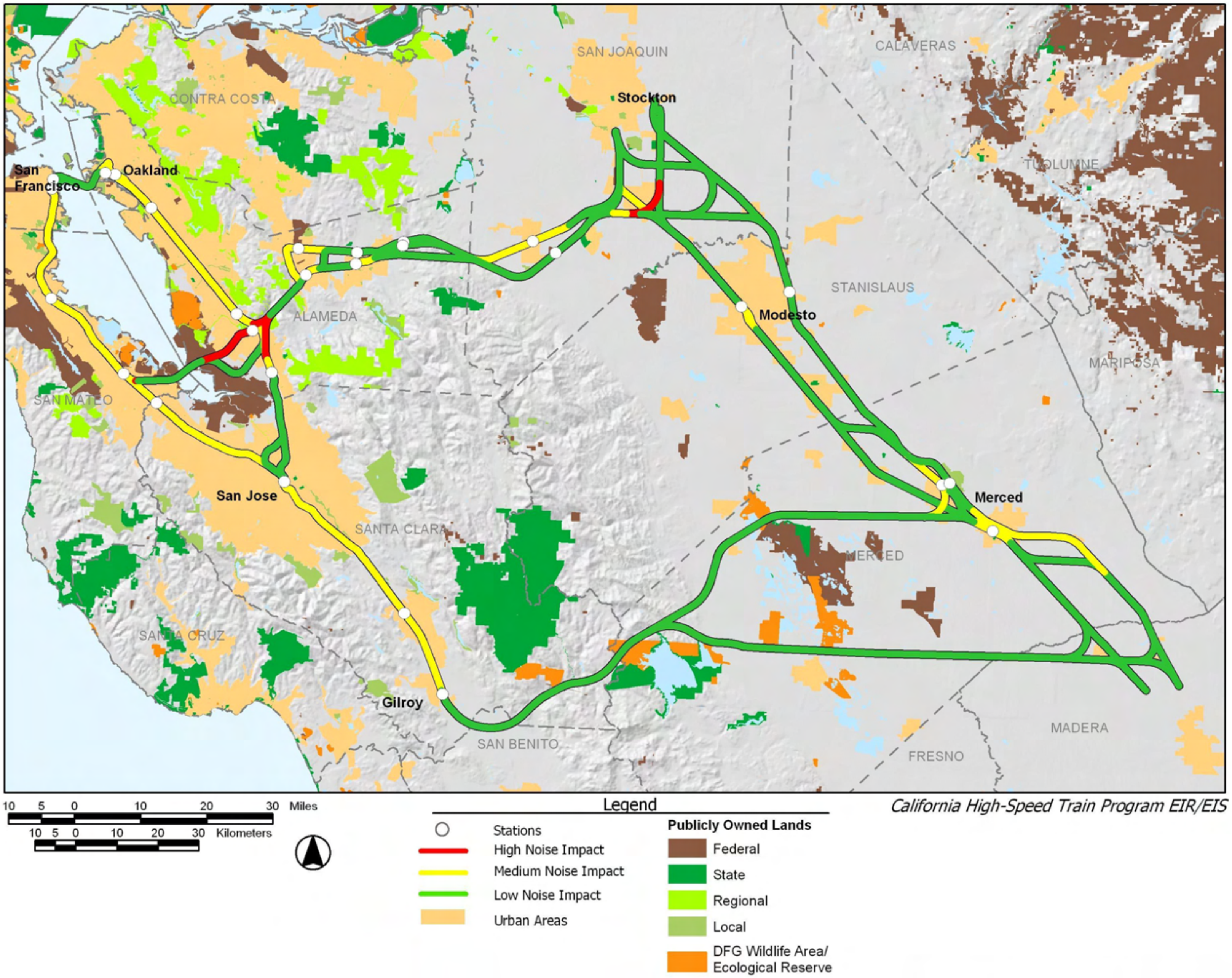
Corridor	Possible Alignments	Alignment Alternative	Total Segment (Miles)	Residential Population	Mixed Use Population	Parkland (Acres)	Hospitals	Schools	Noise Impact Rating*	Vibration Impact Rating
Station Location Options										
West Oakland/7th Street			Ratings are based on alignment alternative that station is on—West Oakland to Niles Junction						Medium	High
12th Street/City Center			Ratings are based on alignment alternative that station is on—12th Street/City Center to Niles Junction						Medium	High
Coliseum/Airport			Ratings are based on alignment alternative that station is on—West Oakland to Niles Junction						Medium	High
Union City (BART)			Ratings are based on alignment alternative that station is on—Niles Junction to San Jose Via Trimble						Medium	Medium
Fremont (Warm Springs)			Ratings are based on alignment alternative that station is on—Niles Junction to San Jose Via Trimble						Medium	Medium
San Jose to Central Valley: Pacheco Pass	1 of 1	Pacheco	70.57	8,029.2	48.4	735.96	0	4	Medium	Medium
	1 of 3	Henry Miller (UPRR Connection)	62.59	0.6	0.6	1,437.29	0	1	Low	Low
		Henry Miller (BNSF Connection)	64.89	0.6	0.6	1,437.29	0	1	Low	Low
		GEA North	51.05	1,496.5	1,361.7	825.92	0	1	Low	Low
Station Location Options										
San Jose (Diridon)			Ratings are based on alignment alternative that station is on—Pacheco						Medium	Medium
Morgan Hill (Caltrain)			Ratings are based on alignment alternative that station is on—Pacheco						Medium	Medium
Gilroy (Caltrain)			Ratings are based on alignment alternative that station is on—Pacheco						Medium	Medium
East Bay to Central Valley: Altamont Pass	1 of 4	I-680/ 580/UPRR	29.99	1,110.1	0.6	94.51	0	1	Low	Low
		I-580/ UPRR	26.54	894.4	0.6	11.61	1	2	Low	Low
		Patterson Pass/UPRR	25.62	2,407.5	0.00	20.40	0	2	Medium	Medium
		UPRR	25.15	2,208.85	0.00	20.40	0	2	Medium	Medium

Corridor	Possible Alignments	Alignment Alternative	Total Segment (Miles)	Residential Population	Mixed Use Population	Parkland (Acres)	Hospitals	Schools	Noise Impact Rating*	Vibration Impact Rating
	1 of 4	Tracy Downtown (BNSF Connection)	50.18	2,596.9	0.00	54.68	0	1	Low	Low
		Tracy ACE Station (BNSF Connection)	50.41	1,005.8	0.00	200.15	0	1	Low	Low
		Tracy ACE Station (UPRR Connection)	29.55	2,693.9	0.00	167.99	0	1	Medium	Low
		Tracy Downtown (UPRR Connection)	33.14	4,258.6	0.00	54.68	0	1	Medium	Low
	2 of 2	East Bay Connections	1.77	1,453.74	4.5	0	0	0	High	High
Station Location Options										
Pleasanton (I-680/Bernal Rd)			Ratings are based on alignment alternative that station is on—Patterson Pass/UPRR						Medium	Medium
Pleasanton (BART)			Ratings are based on alignment alternative that station is on— I-680/ 580/UPRR						Low	Low
Livermore (Downtown)			Ratings are based on alignment alternative that station is on—Patterson Pass/UPRR						Medium	Medium
Livermore (I-580)			Ratings are based on alignment alternative that station is on— I-680/ 580/UPRR						Low	Low
Livermore (Greenville Road/UPRR)			Ratings are based on alignment alternative that station is on—Patterson Pass/UPRR						Medium	Medium
Livermore (Greenville Road/I-580)			Ratings are based on alignment alternative that station is on—I-680/ 580/UPRR						Low	Low
Tracy (Downtown)			Ratings are based on alignment alternative that station is on—Tracy Downtown (UPRR Connection)						Medium	Low
Tracy (ACE)			Ratings are based on alignment alternative that station is on—Tracy ACE Station (UPRR Connection)						Medium	Low

Corridor	Possible Alignments	Alignment Alternative	Total Segment (Miles)	Residential Population	Mixed Use Population	Parkland (Acres)	Hospitals	Schools	Noise Impact Rating*	Vibration Impact Rating
San Francisco Bay Crossings	1 of 2	Trans Bay Crossing – Transbay Transit Center	6.76	0.00	0.00	0.00	0	0	Low	Low
		Trans Bay Crossing – 4th & King	6.5	0.00	0.00	0.00	0	0	Low	Low
	1 of 6	Dumbarton (High Bridge)	18.57	6,848.0	8.9	366.08	0	4	High	High
		Dumbarton (Low Bridge)	18.57	6,848.0	8.9	366.08	0	4	High	High
		Dumbarton (Tube)	18.57	5,267.5	4.5	151.66	0	2	High	High
		Fremont Central Park (High Bridge)	22.29	4,279.9	8.9	572.58	0	3	High	High
		Fremont Central Park (Low Bridge)	22.29	4,279.9	8.9	572.58	0	3	High	High
		Fremont Central Park (Tube)	22.29	3,034.3	8.9	214.42	0	2	Medium	High
Station Location Options										
Union City (Shinn)		Ratings are based on alignment alternative that station is on—Niles Junction to San Jose Via Trimble							Medium	Medium
Central Valley	1 of 6	BNSF – UPRR	86.78	4,000.2	895.5	123.93	1	4	Low	Low
		BNSF	91.29	4,587.5	1052.2	125.57	0	4	Low	Low
		UPRR N/S	87.25	7,401.8	648.7	205.27	2	2	Medium	Low
		BNSF Castle	91.48	7,598.5	1,837.1	494.33	0	7	Medium	Low
		UPRR – BNSF Castle	92.32	11,363.3	2,066.2	699.60	1	6	Medium	Low
		UPRR – BNSF	87.62	7,764.9	1,124.6	329.20	2	3	Medium	Low

Corridor	Possible Alignments	Alignment Alternative	Total Segment (Miles)	Residential Population	Mixed Use Population	Parkland (Acres)	Hospitals	Schools	Noise Impact Rating*	Vibration Impact Rating
Station Location Options										
Modesto (Downtown)			Ratings are based on alignment alternative that station is on—UPRR N/S						Medium	Low
Briggsmore (Amtrak)			Ratings are based on alignment alternative that station is on—BNSF						Low	Low
Merced (Downtown)			Ratings are based on alignment alternative that station is on—UPRR-BNSF Castle						Medium	Low
Castle AFB			Ratings are based on alignment alternative that station is on—BNSF Castle						Medium	Low

*Accounts for Grade Crossing Elimination on alignment segments on or adjacent to existing non-grade separated tracks.



U.S. Department of Transportation
Federal Railroad Administration

Figure 3.4-6
Potential Noise Impact Levels

Oakland to San Jose

Although the HST service in the Oakland to San Jose corridor would be going through densely populated communities, the alignment alternatives in this corridor were rated as having a medium level of potential noise impacts because the HST would be traveling at reduced speeds and the communities would benefit from grade separation improvements for existing services and electrification of the railroad.

The alignment alternatives through Oakland to Niles are rated medium for noise and high for vibration because of the higher population densities and the proximity of a school to the segments. The 12th Street/City Center to Niles Junction alignment alternative would have an additional 4.8 mi of vibration impact rated high than the West Oakland to Niles Junction alternatives because of the segment between 12th Street/City Center to Jack London Square. Noise impacts are the same for these two alternatives.

The alignment alternative from Niles Junction to San Jose via Trimble has 6 mi of noise impacts rated as medium and vibration impacts rated high; the Niles Junction to San Jose via I-880 alignment alternative is similar but has an additional 2.9 mi of medium rated vibration impact.

San Jose to Central Valley

The San Jose to Central Valley corridor is rated as having medium potential for noise impacts. Although the HST system could reach speeds as great as 186 mph (299 kph) through this area, the densities are less than on the San Francisco Peninsula or the East Bay, and the communities would receive considerable benefit from the elimination of up to 24 grade crossings.

Along the Pacheco alignment alternative from Diridon to Gilroy, there are 42.4 miles where noise impacts are rated medium to high and vibration impacts are rated medium. Four schools are located along this alignment, and there are 131 ac of parkland and varying residential populations.

All the alignment alternatives for mountain crossings between the Bay Area and the Central Valley are through sparsely populated areas but would introduce new noise sources along corridors through wilderness areas where the alignment is at grade or elevated.

From San Luis Reservoir to Henry Miller Wye, there are three alignment alternatives. The noise and vibration impacts in the UPRR Connection and BNSF Connection alignment alternatives are rated low. Both these alignment alternatives pass through areas with little to no residential population. The GEA North alignment alternative is located closer to populated areas and the noise and vibration impacts in this alignment alternative are rated medium along the 7.7 miles between GEA Atwater Wye to the BNSF.

Eastbay to Central Valley

In the Eastbay to Central Valley corridor, which extends from Niles Canyon to the County Line through the Altamont Pass, there are four alignment alternatives. The I-680/580/UPRR alignment alternative is rated a medium noise and vibration impact from Sunol to El Charo Road, which is made up of 9.7 mi of sparsely populated residents with 7 ac of parkland. The I-580/UPRR alignment alternative is rated a high impact for noise and vibration along the Pleasanton to El Charo 1.7 mi segment. The Patterson Pass/UPRR alignment alternative has 8.0 mi of noise and vibration impacts rated medium to high from Pleasanton to the Patterson Pass cut off. The UPRR alignment is the same as Patterson Pass/UPRR with similar impacts along the same 8.0 mi length.

Of the four alignments from Tracy to Escaton Wye, the segment from southeast Manteca to the BNSF connection would be ranked the highest in noise and vibration impacts.

In the East Bay alignment alternative, the Niles to Niles Wye segment is rated a high vibration impact through Fremont, and the segment through Union City is rated a low vibration impact. Noise impacts are the same along these segments.

San Francisco Bay Crossings

In the San Francisco Bay Crossings corridor, the Trans Bay Crossing alignment alternative would be through a tunnel and is rated low for noise and vibration impacts. Of the six alignment alternatives from the Dumbarton Wye to Niles Wye, the Dumbarton Tube alignment alternative is rated the highest noise and vibration impact over the greatest distance, approximately 12 mi.

Central Valley

Through the Central Valley, most of the HST Alignment Alternatives are rated as low potential noise impact due generally to the sparseness of residential land use and the extent of open space along most of the length of the options—even though the proposed HST service would be operating at maximum speeds throughout most of the Central Valley. However, there are a number of locations in the Central Valley where the various alignment alternatives pass through populated areas and have high potential noise impact ratings for short segments. Examples include portions of Modesto and Merced that could be exposed to higher noise levels from HST operations.

Through many of the cities in the Central Valley, the HST is proposed to be on aerial structure, primarily to reduce potential conflicts with freight railroad spur tracks or freight railroad yards. The vertical elevation of the aerial structure would allow potential noise impacts to extend further than they would at grade.

Through the Central Valley corridor, from North Stockton to the Henry Miller BNSF Wye, the alignment alternatives with the highest ranked noise impact are the BNSF Castle and UPRR – BNSF Castle alternatives, with 16.8 mi that are rated high noise impact and medium vibration impact.

C. SHORT-TERM CONSTRUCTION NOISE AND VIBRATION

Construction Noise Levels

Noise impacts from construction of the project will be generated by heavy equipment used during major construction periods as close as 50 ft from existing structures along the alignment. Table 3.4-5 shows the estimated maximum noise levels for the different stages of at-grade construction at 100 ft from a receiver.

Table 3.4-5
Estimated Peak Hour Construction Noise Levels

Construction Phase	Loudest Equipment	Noise Level at 100 ft Lmax (dBA)
Clearing and grubbing	Bulldozer, backhoe, haul trucks	86
Earthwork	Scraper, bulldozer	88
Foundation	Backhoe, loader	85
Structures	Crane, loader, haul truck	86
Base preparation	Trucks, bulldozer	88
Paving	Paver, pumps, haul trucks	89
Source: *Transit Noise and Vibration Impact Assessment* (U.S. Department of Transportation 2006).		

Construction Vibration Levels

Common vibration-producing equipment used during at-grade construction activities include jackhammers, pavement breakers, hoe rams, augur drills, bulldozers, and backhoes. Pavement breaking and soil compaction would probably be the activities that produce the highest level of vibration. Table 3.4-6 presents various types of construction equipment measured under a wide variety of construction activities, with an average of source levels reported in terms of velocity levels. Although the table gives one level for each piece of equipment, it should be noted that there is a considerable variation in reported ground vibration levels from construction activities. The data provide a reasonable estimate for a wide range of soil conditions.

Table 3.4-6
Vibration Source Levels for Construction Equipment

Equipment	Peak Particle Velocity at 25 Ft (inches per second)	Approximate Velocity Level at 25 Ft
Pile driver (impact)		
Upper range	1.518	112
Typical	0.644	104
Pile driver (sonic)		
Upper range	0.734	105
Typical	0.170	93
Clam shovel drop (slurry wall)	0.202	94
Hydromill (slurry wall)		
In soil	0.008	66
In rock	0.017	75
Large bulldozer	0.089	87
Caisson drilling	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58
Velocity level = Root mean square velocity in decibels (VdB) relative to 1 micro-inch/second. Source: *Transit Noise and Vibration Impact Assessment* (U.S. Department of Transportation 2006).		

3.4.4 Role of Design Practices in Avoiding and Minimizing Effects

Because of the high-speed alignment requirements of the HST system, significant portions of the alignment alternatives are in a tunnel or trench section. For these portions of the system, the potential for noise impacts is mostly eliminated. The tunnel cross sections are designed (per established engineering criteria) to provide sufficient cross-sectional area to avoid potential aerodynamic effects at the tunnel portals caused by trains operating at maximum speed.

At similar speeds, HSTs generate significantly less noise than commuter and freight trains. This is primarily to the result of the use of electric power versus diesel engines, higher quality track interface, and smaller, lighter, more aerodynamic trainsets. The use of electric power units would not have the engine rumble associated with diesel-powered locomotives. Although wheel/track interface is a significant source of train noise, HST track beds and rails are designed and maintained to very high geometric tolerances and standards, which would greatly minimize track noise that is prevalent with commuter/freight tracks throughout the study region.

Another reason HST noise impacts are less than commuter or freight trains is that high speeds would result in short duration noise events compared with conventional trains (a few seconds at the highest speeds versus 10 to 20 seconds for conventional passenger trains and well over 1 minute for freight trains).

The HST system would be fully grade separated from all roadways. In the urban areas, where potential for noise impacts is typically at the highest levels, the HST system would be predominantly in or adjacent to existing rail corridors, and the HST Alignment Alternatives often include the grade separation of the existing tracks. Grade separations completed with the HST system in corridors such as these would eliminate horn sounding and bells at existing grade crossings and would result in noise benefits that would offset much of the HST noise impacts.

3.4.5 Mitigation Strategies and CEQA Significance Conclusions

Based on the analysis above, and considering the design practices described in section 3.4.4, each of the HST Alignment Alternatives would have significant noise and vibration impacts, as detailed in Table 3.4-4. The HST Alignment Alternatives would create significant long-term noise and vibration impacts from introduction of a new transportation system. At the same time, the HST Alignment Alternatives would create some long-term noise reduction benefits because noise sources would be eliminated with grade separation of existing grade crossings. It is possible that at the future project-level of analysis, refined data and information would confirm that some sections of the alignment alternatives would result in less-than-significant noise and vibration impacts (i.e., through the Transbay Tunnel); however, for purposes of the programmatic analysis, the long-term noise and vibration impacts are considered significant for all sections. In addition, the HST Alignment Alternatives would involve significant short-term noise and vibration impacts from construction.

General mitigation strategies are discussed in this program-level review of potential noise impacts associated with proposed alternatives that would reduce the impacts. General vibration mitigation strategies are less predictable at a program level of analysis because of the site-specific nature of vibration transmission through soil along the alignment. More detailed mitigation strategies for potential noise and vibration impacts would be developed in the next stage of environmental analysis. Noise and vibration mitigation measures can generally be applied to the source (train and associated structures), the path (area between train and receiver), and/or the receiver (property or building). An HST system would be designed and developed to meet state-of-the-art technology specifications for noise and vibration, based on the desire to provide the highest-quality train service possible. Trains and tracks would be maintained in accordance with all applicable standards to provide reliable operations.

Treatments, such as sound insulation or vibration controls to affected buildings, may be difficult to implement for the potentially numerous properties adjacent to the right-of-way. Such treatments require protracted implementation procedures and separate design considerations. The most feasible and effective mitigation treatments are typically those involving the path. These mitigation measures can often be applied to the path within the right-of-way, either under or adjacent to the tracks. Potential noise impacts can be reduced substantially by the installation of sound barrier walls constructed to shield receivers from train noise. For vibration mitigation, several track treatments may be considered for reducing train vibrations. Determining the most appropriate treatment would depend on the site-specific ground conditions along the corridor. This program-level analysis has identified areas where future analysis should be given to potential HST-induced vibrations. The type of vibration mitigation and expected effectiveness will be determined as part of the second-tier project-level environmental analyses.

A. NOISE BARRIERS

Noise barriers are often a practical way to reduce noise impacts from the proposed HST system. The representative typologies considered the mitigation potential of noise barriers for certain areas. In most cases the application of appropriately dimensioned noise barriers next to the tracks could reduce potential noise impacts from FRA's severe noise impact category to moderate, and to the no impact category in some locations. The design of noise barriers appropriate for the proposed HST right-of-way line would depend on the location and height of noise-sensitive buildings, as well as the speeds of the trains. Noise barriers 8–10 ft (2–3 m) tall could be installed where speeds are relatively low (i.e., wheel/rail noise dominates). Higher noise barriers of 12–16 ft (4–5 m) might be used to reduce noise to taller buildings or where speeds are high in noise-sensitive areas. In many locations, noise barriers could be installed on one side of the track only because of the location and proximity of noise-sensitive areas.

Application of mitigation to the proposed HST system would result in a considerable reduction of potential noise impacts. The estimates obtained from the results of the representative typologies showed noise barriers to be effective in reducing the potential noise impact rating by one category, for example, from high to medium or from medium to low. Consequently, HST Alignment Alternatives with high rating would be adjusted down to, at most, a medium rating.

The cost of constructing a noise barrier on one side of a rail line is estimated at approximately $1 million per mi ($625,000 per km) for a concrete wall of 12 ft (4 m) in height. Conservatively, a unit cost of $1.5 million per mi ($937,500 per km) was applied to portions of the HST Alignment Alternatives with high potential noise impact ratings. The procedure was repeated for all segments with a medium rating, thereby reducing these HST noise impact ratings to low. This approach was intended to show that mitigation is possible and to provide a rough estimate of potential mitigation costs, recognizing that specific mitigation would be developed as a part of project-level review.

The results in Table 3.4-7 show the potential mitigation costs for the HST Alignment Alternatives. This analysis included noise mitigation (barrier walls) for 1.7 to 42.4 route miles (2.7 to 68.2 route km) of the proposed HST alignments with medium to high noise impacts.

Table 3.4-7
Potential Length and Cost of Noise Mitigation by Alignment

	Noise Mitigation Length in Miles (Km)	Noise Barrier Cost (in millions of dollars)
San Francisco to San Jose: Caltrain		
San Francisco to Dumbarton	26.9 (43.2)	40.3
Dumbarton to San Jose	18.7 (30.1)	28.0
Oakland to San Jose: Niles/I-880		
West Oakland to Niles Junction (1 of 2)	13.6 (21.9)	20.4
12th Street/City Center to Niles Junction (2 of 2)	13.6 (21.9)	20.4
Niles Junction To San Jose via Trimble (1 of 2)	6.0 (9.6)	9.0
Niles Junction to San Jose via I-880 (2 of 2)	6.0 (9.6)	9.0
San Jose to Central Valley: Pacheco Pass		
Pacheco	42.4 (68.2)	63.6
Henry Miller (UPRR Connection) (1 of 3)	0	0
Henry Miller (BNSF Connection) (2 of 3)	0	0
GEA North (3 of 3)	7.7 (12.4)	11.6
East Bay to Central Valley: Altamont Pass		
I-680/I-590/UPRR	9.7 (15.6)	14.6
I-580/UPRR	1.7 (2.8)	2.6

	Noise Mitigation Length in Miles (Km)	Noise Barrier Cost (in millions of dollars)
Patterson Pass/UPRR	8.0 (12.9)	12.0
UPRR	14.8 (23.7)	22.1
Tracy Downtown (BNSF Connection)	3.0 (4.8)	4.4
Tracy ACE Station (BNSF Connection)	8.2 (13.2)	12.3
Tracy ACE Station (UPRR Connection)	20.0 (32.2)	30.0
East Bay Connections	1.8 (2.8)	2.7
San Francisco Bay Crossings		
Trans Bay Crossing – Transbay Transit Center	0 (0)	0
Trans Bay Crossing – 4th & King	0 (0)	0
Dumbarton (High Bridge)	18.6 (29.9)	27.9
Dumbarton (Low Bridge)	18.6 (29.9)	27.9
Dumbarton (Tube)	11.0 (17.6)	16.4
Freemont Central Park (High Bridge)	22.3 (35.6)	33.4
Freemont Central Park (Low Bridge)	22.3 (35.6)	33.4
Freemont Central Park (Tube)	22.3 (35.6)	33.4
Central Valley		
BNSF-UPRR	10.7 (17.2)	16.1
BNSF	10.9 (17.6)	16.4
UPRR N/S	13.1 (21.0)	19.6
BNSF Castle	16.8 (27.0)	25.2
UPRR – BNSF Castle	25.5 (41.1)	38.3
UPRR – BNSF	19.4 (31.3)	29.1

B. VIBRATION MITIGATION

The following mitigation strategies can be refined and applied at the project-specific level and will reduce the vibration impact:

- Specify the use of train and track technologies that minimize ground vibration, such as state-of-the-art suspensions, resilient track pads, tie pads, ballast mats, or floating slabs.
- Phase construction activity, use low impact construction techniques, and avoid use of vibrating construction equipment where possible to avoid vibration construction impacts.

Vibration mitigation is less predictable at a program level of analysis because of the site-specific nature of vibration transmission through soil along the alignment. However, an estimate can be made of the length of corridor where vibration mitigation may need to be considered by totaling the segments with potential vibration impact rating of high. The results are shown in Table 3.4-8 and Figure 3.4-7. The range is 1.7–42.4 mi (2.7 to 68.2 km) to be considered for mitigation, depending on which option is chosen. Although the mitigation measures will reduce vibration impact levels, at the programmatic level it is uncertain whether the reduced vibration levels will be below a significant impact. The type of vibration mitigation and expected effectiveness to reduce the vibration impacts of

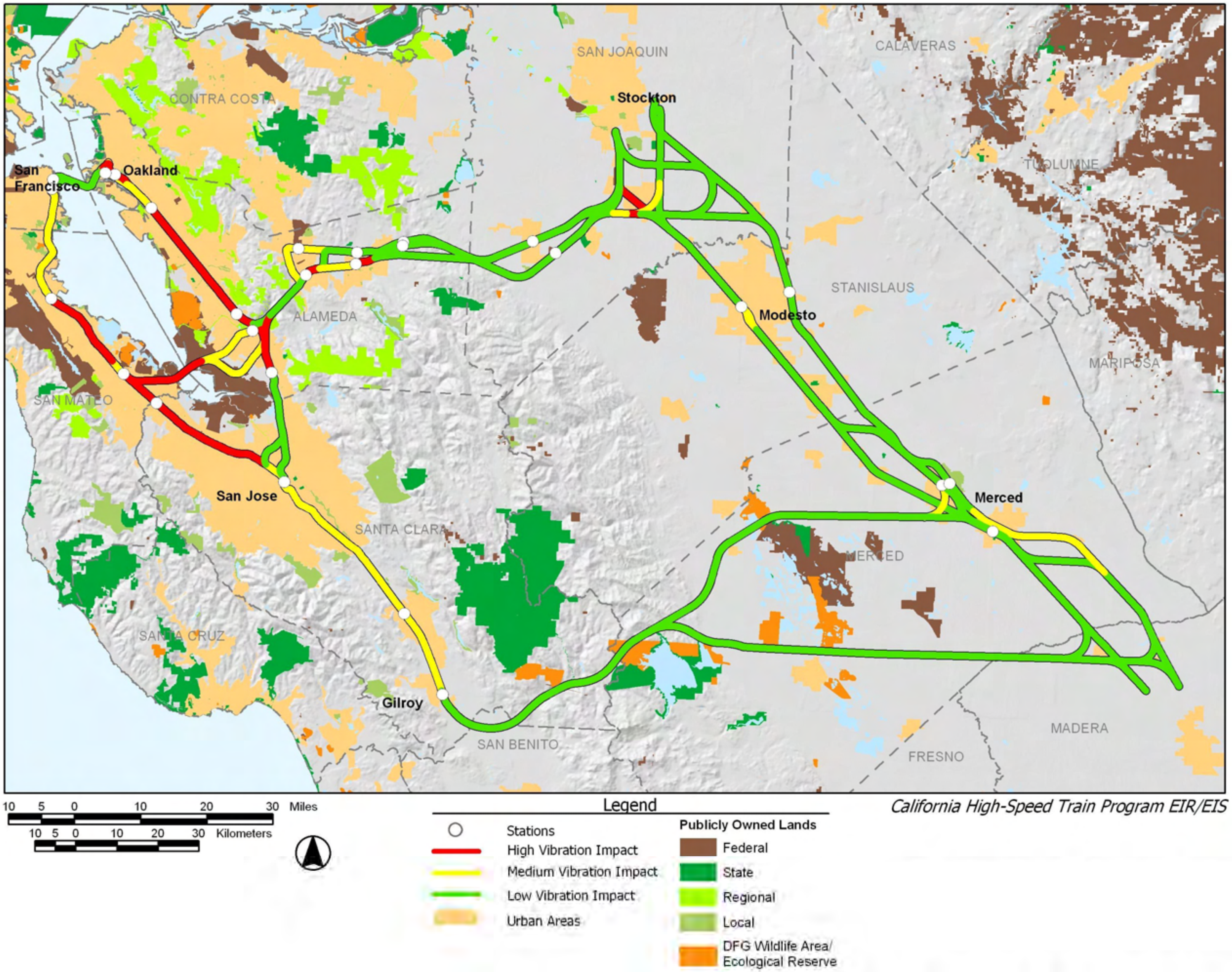


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Figure 3.4-7
Potential Vibration Impact Levels

the HST Alignment Alternatives to a less-than-significant level will be determined as part of the second-tier project-level environmental analyses.

C. CONSTRUCTION MITIGATION

Potential mitigation strategies for construction noise impacts associated with the HST system are listed below.

- Construction noise could be reduced by using enclosures or walls to surround noisy equipment, installing mufflers on engines, substituting quieter equipment or construction methods, minimizing time of operation, and locating equipment farther from sensitive receptors.
- Construction operations could be suspended between 7:00 p.m. and 7:00 a.m. and/or on weekends and holidays in residential areas.
- Contractors could be required to comply with all local sound control and noise-level rules, regulations, and ordinances.
- Equip each internal combustion engine with a muffler of a type recommended by the manufacturer.

Table 3.4-8
Length of Potential Vibration Impact by Alignment

	Length of Medium Impact in Miles (km)	Length of High Impact in Miles (km)
San Francisco to San Jose		
San Francisco to Dumbarton	16.3 (26.2)	10.6 (17.0)
Dumbarton to San Jose	2.9 (4.7)	18.7 (30.1)
Oakland to San Jose		
West Oakland to Niles Junction (1 of 2)	8.4 (13.6)	5.2 (8.2)
12th Street/City Center to Niles Junction (2 of 2)	3.6 (5.8)	10.0 (16.1)
Niles Junction To San Jose via Trimble (1 of 2)	0 (0)	6.0 (9.6)
Niles Junction to San Jose via I-880 (2 of 2)	2.9 (4.7)	6.0 (9.6)
San Jose to Central Valley: Pacheco Pass		
Pacheco	42.4(68.2)	0 (0)
Henry Miller (UPRR Connection) (1 of 3)	0 (0)	0 (0)
Henry Miller (BNSF Connection) (2 of 3)	0 (0)	0 (0)
GEA North (3 of 3)	7.7 (12.4)	0 (0)
East Bay to Central Valley: Altamont Pass		
I-680/I-590/UPRR	9.7 (15.6)	0 (0)
I-580/UPRR	0 (0)	1.7 (2.8)
Patterson Pass/UPRR	4.1 (6.5)	4.0 (6.4)
UPRR	4.1 (6.5)	4.0 (6.4)
Tracy Downtown (BNSF Connection)	0 (0)	1.1 (1.7)
Tracy ACE Station (BNSF Connection)	0 (0)	1.1 (1.7)
Tracy ACE Station (UPRR Connection)	5.3 (8.5)	1.1 (1.7)
East Bay Connections	0 (0)	0.6 (1.0)

	Length of Medium Impact in Miles (km)	Length of High Impact in Miles (km)
San Francisco Bay Crossings		
Trans Bay Crossing – Transbay Transit Center	0 (0)	0 (0)
Trans Bay Crossing – 4th & King	0 (0)	0 (0)
Dumbarton (High Bridge)	6.8 (11.0)	11.8 (18.9)
Dumbarton (Low Bridge)	6.8 (11.0)	11.8 (18.9)
Dumbarton (Tube)	6.8 (11.0)	11.8 (18.9)
Freemont Central Park (High Bridge)	12.9 (20.8)	9.4 (15.1)
Freemont Central Park (Low Bridge)	12.9 (20.8)	9.4 (15.1)
Freemont Central Park (Tube)	12.9 (20.8)	9.4 (15.1)
Central Valley		
BNSF-UPRR	0 (0)	0 (0)
BNSF	0 (0)	0 (0)
UPRR N/S	0 (0)	6.1 (9.8)
BNSF Castle	16.8 (27.0)	0 (0)
UPRR – BNSF Castle	16.8 (27.0)	6.1 (9.8)
UPRR – BNSF	0 (0)	6.1 (9.8)

Other measures that should be considered include the following:

- Specifying the quietest equipment available would reduce noise by 5–10 dBA.
- Turning off construction equipment during prolonged periods of nonuse would eliminate noise from construction equipment during those periods.
- Requiring contractors to maintain all equipment and train their equipment operators would reduce noise levels and increase efficiency of operation.
- Locating stationary equipment away from noise-sensitive receptors would decrease noise impact from that equipment in proportion to the increased distance.

The above mitigation strategies are expected to reduce the short-term and long-term noise impacts of the HST Alignment Alternatives to a less-than-significant level. Additional environmental assessment would allow a more precise evaluation in the second-tier project-level environmental analyses.

3.4.6 Subsequent Analysis

A. NOISE ANALYSIS

FRA provides guidance for two levels of analysis in project environmental review, a general assessment method to further quantify the potential noise impacts in locations identified by the screening procedure and a detailed analysis procedure for evaluating suggested noise mitigation at locations where further studies show there is potential for significant impacts. The process is designed to focus on problem areas as more detail becomes available during project development. Subsequent analysis would proceed along the following lines.

Ambient noise conditions

The existing ambient noise environment is described by assumptions in the screening procedure. However ambient noise values would be estimated at the project-level analysis based on limited measurements in the general assessment and would be thoroughly measured in the detailed analysis. A measurement program involving both long-term and short-term noise monitoring would be performed at selected locations to document the existing noise environment. Because it would be impractical to measure noise everywhere, the monitoring would be supplemented by estimates of noise environments at locations considered to be typical of others. Guidelines for characterizing the existing conditions are provided by the FRA manual.

Project Noise Conditions

A generic HST is used in the screening procedure, but a more specific train type, speed profile, and operation plan would be available for more refined projections of noise levels in the next stage of environmental analysis.

Noise Propagation Characteristics

The screening procedure assumes flat terrain with noise emanating from a source unhindered by landforms and human-made structures. The next stage of analysis would incorporate topography as well as consideration of shielding by buildings, vegetation, and other natural features in a particular corridor.

Impact Criteria

The screening procedure accounts for all noise-sensitive land use categories that may be exposed to noise levels exceeding the threshold of impact. In the next stage of analysis, assessments using the full, three-level FRA impact criteria would be performed (U.S. Department of Transportation 2005). This more detailed assessment would more specifically identify locations where potential impacts may occur and locations where potentially high impact may occur and would provide for consideration of specific mitigation measures where appropriate.

Mitigation

Noise abatement is discussed generally in the screening procedure, and areas are identified where more detailed analysis should be focused in the future to integrate a proposed HST system into the existing environment. As more detail becomes available in the general assessment phase, there may be many areas that were identified as potentially impacted during screening analysis for which further analysis would not be needed, because they would not be impacted. The detailed analysis would provide information useful for the engineering design of mitigation measures. These measures would be considered in the project-level environmental review, and potential visual and shadow impacts of noise barriers would also be considered.

B. VIBRATION ANALYSIS

The steps involved in the more detailed analysis of ground-borne vibration would be similar to those for noise. The major difference would be the need for study of site-specific ground-borne vibration characteristics. Considerable variation of soil conditions may occur along the corridor, resulting in some locations with significant levels of vibration from the HST and other locations at the same distance from the track with almost imperceptible vibration levels. Determining the potential vibration characteristics in the detailed analysis would involve a measurement program performed according to the method described in the FRA guidance manual (U.S. Department of Transportation 2005). This method would allow for the prediction of vibration levels and frequency spectrum information, which is valuable not only in the assessment of impact but also in the consideration of mitigation measures.